

| |
|----------------|
| Pre-Associated |
| Pending Insert |
| Valid |
| Pending Delete |
| Deleted |
| Hidden |
| Invalid |

Table 1

[0017] Thus, for example, an insertion operation includes state transitions between a pre-associated state, in which an element 245 to be inserted into data structure 240 is created, to a pending insert state, in which the element 245 to be inserted is linked to the data structure 240 at an insertion point while an existing link at the insertion point is maintained, to a valid state, in which the existing link at the insertion point is removed.

10 [0018] In similar fashion, a deletion operation includes state transitions between a valid state in which an element 245 to be deleted from data structure 240 remains linked to other elements 245 at a deletion point, to a pending delete state in which a link is created between the elements 245 in data structure 240
15 linked to the element 245 to be deleted, to a deleted state, in

which the element 245 to be deleted is no longer linked to the data structure 240.

[0019] Additional states include an invalid state and a hidden state. An example of element 245 being in an invalid state is when the element 245 has been deleted from the data structure but the deleted element still physically exists. Additional clean up processes physically delete the deleted element 245. Preferably, such clean up processes execute in the commit phase of step 140 (FIG. 1).

[0020] An element 245 is in the hidden state following a rollback request in which the element 245 to be inserted is hidden from all operations. As further described herein, an element 245 in the hidden state may undergo a state transition from the hidden state to the invalid state as well as a state transition from the hidden state to the pending insert state.

[0021] As explained herein, state transitions are executed in either the update phase of step 130 or the commit phase of step 140 (FIG. 1), those executed in the update phase of step 130 including a first set of state transitions and those executed in the commit phase of step 140 including a distinct second set of state transitions. Table 2 lists state transitions and the phase in which each is executed.

| Update Phase | Commit Phase |
|----------------------------------|--|
| Valid to Pending Delete | Pending Insert to Valid |
| Pre-associated to Pending Insert | Pending Delete to Invalid |
| Pending Insert to Hidden | Hidden to Invalid |
| | Invalid to Deleted |
| | Pending Delete to Valid (rollback only) |
| | Hidden to Pending Insert (rollback only) |
| | Pending Insert to Invalid (rollback only) |

Table 2

[0022] The update data 250 (FIG. 2) are developed during the update phase of step 130 (FIG. 1) as further described herein.

5 Such development involves navigation of the data structure 240 (FIG. 2). Thus for example, the state transition from the valid state to the pending delete state involves navigation to the point of deletion in the data structure 240. Such navigation